REPORT

ON

VEGETABLE PARCHMENT

BY

A. W. HOFMANN, L.L.D. F.R.S.

PROFESSOR OF CHEMISTRY TO THE GOVERNMENT SCHOOL OF MINES.

THOMAS DE LA RUE & CO.

110 BUNHILL ROW, LONDON.

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PROFESSOR OF CHEMISTRY TO THE GOVERNMENT SCHOOL OF MINES.

ADDRESSED TO MESSRS. THOMAS DE LA RUE AND CO.

Royal College of Chemistry,
August 12, 1858.

GENTLEMEN,

In accordance with your request, I have carefully examined the new material, called Vegetable Parchment, or Parchment Paper, which you have submitted to me for experiment, and I now beg to communicate to you the results at which I have arrived.

I may here state that the article in question is by no means new to me; I became acquainted with this remarkable production very soon after Mr. W. E. Gaine had made known his results, and I have now specimens before me which came into my possession as early as 1854. My attention was again called to the subject in 1857, when my friend, Mr. Barlow, delivered an interesting discourse upon Vegetable Parchment, at one of the Friday evening meetings of the Royal Institution.* Hitherto, however, I had not myself experimented upon the subject.

The substance submitted to me for examination exhibits in most of its properties so close an analogy with animal membrane, that the name adopted for the new material seems fully justified. In its appearance, Vegetable Parchment greatly resembles Animal Parchment; the same peculiar tint, the same degree of translucency, the same transition from the fibrous to the hornlike condition. Vegetable like Animal Parchment, possesses a high degree of cohesion, bearing frequently repeated bending and rebending, without showing any tendency to break in the folds; like the latter, it is highly hygroscopic, acquiring by the absorption of moisture increased flexibility and toughness. Immersed in water, Vegetable Parchment exhibits all the characters of animal membrane, becoming soft and slippery by the action of water, without, however, losing

* On some Modifications of Woody Fibre, and their Applications, by the Rev. J. Barlow, M.A., F.R.S., &c.—*Proceedings of the Royal Institution of Great Britain.*

in any way its strength. Water does not percolate through Vegetable Parchment, although it slowly traverses this substance like animal membrane by endosmotic action.

In converting unsized paper into Vegetable Parchment or Parchment Paper by the process recommended by Mr. Gaine, viz: immersion for a few seconds into oil of vitriol, diluted with half its volume of water, I was struck by the observation, how narrow are the limits of dilution, between which the experiment is attended with success. By using an acid containing a trifle more of water, than the proportion indicated, the resulting parchment is exceedingly imperfect; whilst too concentrated an acid either dissolves or chars the paper. Time, also, and temperature are very important elements in the successful execution of the process. If the acid bath be only slightly warmer than the common temperature, 60° F. (15.5° C.)—such as may happen when the mixture of acid and water has not been allowed sufficiently to cool—the effect is very considerably modified. Nor do the relations usually observed between time, temperature and concentration, appear to obtain with reference to this process; for an acid of inferior strength, when heated above the common temperature, or allowed to act for a longer time, entirely fails to produce the desired result. Altogether the transformation of ordinary paper into Vegetable Parchment is an operation of considerable delicacy, requiring a great deal of practice; in fact, it was not until repeated failures had pointed out to me the several conditions involved in this reaction, that I succeeded in producing papers, in any way similar to those which you have submitted to me for experiment.

Mr. Barlow in the discourse on Woody Fibre to which I have alluded, records some experiments establishing that unsized paper, by its conversion into Vegetable Parchment, receives no appreciable increase of weight. These experiments rendered it very probable that the action of sulphuric acid in this case is essentially molecular, and that the chemical composition of the substance of the paper by its conversion into parchment is not altered. It remained to establish this point experimentally. For this purpose several of the specimens of commercial Vegetable Parchment, without any further purification, were submitted to analysis. The result showed that—with the exception of about 0.9 per cent of mineral matter, a quantity, not much exceeding the amount which is present in the better varieties of ordinary paper—the substance of Vegetable Parchment *is identical in composition with Cellulose or Woody Fibre.* The analytical experiments demonstrate—as might have been expected—that the extraordinary change, which the properties of paper undergo during its transformation, depends solely and exclusively upon a molecular re-arrangement of the constituents, and not upon

any alteration in the composition of the paper. In this respect, the action which sulphuric acid exerts upon Woody Fibre may be compared to the transformation of Woody Fibre, under the protracted influence of the same agent, into *Dextrin*, a substance altogether different from fibre, but still identical with it in composition. Vegetable Parchment may, in fact, be looked upon as the connecting link between cellulose on the one hand, and dextrin on the other.

Thus it is obvious that the transformation, under the influence of sulphuric acid, of paper into Vegetable Parchment, is altogether different from the changes which vegetable fibre suffers by the action of nitric acid; the cellulose receiving, during its transition into *pyroxylin* and *gun-cotton*, the elements of hyponitric acid in exchange for hydrogen, whereby its weight is raised, in some cases by forty, in others, by as much as sixty per cent. As the nitro-compounds thus produced, differ so essentially in composition from the original cellulose, we are not surprised to find them also endowed with properties altogether different; such as, increased combustibility, change of electrical condition, altered deportment with solvents, &c., whilst Vegetable Parchment, being the result of a molecular transposition only, in which the paper has lost nothing and gained nothing, retains all the leading characters of vegetable fibre, exhibiting only certain modifications which confer additional value upon the original substance.

The nature of the reaction which gives rise to the formation of Vegetable Parchment having been satisfactorily established, it became a matter of importance to ascertain whether the processes used for the mechanical removal of sulphuric acid from the paper had been sufficient to produce the desired effect. It is obvious that the valuable properties acquired by paper, by its conversion into Vegetable Parchment can be permanently secured only by the entire absence or perfect neutralization of the agent which produced them. The presence of even traces of *free* sulphuric acid in the paper would rapidly loosen its texture, the paper would gradually fall to pieces, and one of the most important applications which suggest themselves, viz: the use of Vegetable Parchment in the place of animal parchment for legal documents would thus, at once, be lost.

Examination of the Vegetable Parchment for free sulphuric acid was, therefore, one of the principal points to which I had to direct my attention. From the description of the process adopted in preparing the new material, viz.: long continued mechanical washing with cold water, immersion in a dilute solution of caustic ammonia, and, lastly, renewed washing with water, the absence in it of free sulphuric acid may be at once inferred on scientific grounds. For supposing that the first process of washing had left any free

sulphuric acid in the paper, this acid, after immersion of the paper in caustic ammonia, for which it has so strong an attraction, could have remained only in the form of sulphate of ammonia, a salt of perfectly neutral composition, in which the acid character of sulphuric acid is entirely lost. Now, sulphate of ammonia is a most stable compound, which begins to decompose only at about 536° F. (280° C.), a temperature at which paper is completely destroyed; and even then, no free sulphuric acid is to be found amongst the products of decomposition. But the paper is washed again after treatment with ammonia, and, obviously, only traces of sulphate of ammonia can remain in it.

The absence of free sulphuric acid in the parchment paper was, moreover, established by direct experiment. The most delicate test papers left for hours in contact with moistened Vegetable Parchment, did not exhibit the slightest change of colour. Several square feet of parchment paper were cut up into small pieces and boiled for half a day with water; the liquid was filtered off, and the solution concentrated to a few drops. The liquid thus obtained, was found to contain sulphate of lime and sulphate of ammonia, and slightly reddened blue litmus-paper, in consequence of the presence of the sulphate of ammonia, which, though neutral of composition, like so many other neutral salts, affects vegetable colours. In fact on dissolving pure sulphate of ammonia, which had been crystallized, from a solution purposely rendered alkaline by the addition of ammonia, a solution was obtained, exhibiting even a greater effect upon blue litmus-paper. The absence of free sulphuric acid in this liquid was, moreover, directly proved, for paper moistened with this concentrated liquid and dried at 212° F. (100° C.) exhibited no kind of disintegration, the liquid producing, in fact, not more effect upon paper than common water. This experiment appears to me conclusive; for supposing even an extremely minute quantity of free sulphuric acid in the Vegetable Parchment, it is obvious that, by withdrawing this acid from a considerable quantity of paper, and concentrating its action upon a single strip at as high a temperature as that of boiling water, a very perceptible effect of disintegration would have resulted.

From the above considerations and experiments, I conclude that Vegetable Parchment as prepared by the process which you describe in your letter, and as represented by the samples accompanying it, *does not contain a trace of free sulphuric acid.* I conclude, moreover, that the sulphates, of which minute quantities are present in this as in almost every variety of paper, *cannot possibly develope free sulphuric acid* by any influences, to which the Vegetable Parchment is likely to become exposed. There is no reason, therefore, to believe that Vegetable Parchment, prepared, as it is, by

one of the most powerful agents of decomposition, carries within itself the germ of its own destruction.

In addition to the experimental evidence already adduced, it may be stated that if such were the case, a change would become perceptible after a comparatively limited period; but specimens of Vegetable Parchment which have been in my possession for upwards of four years, cannot by any possibility be distinguished from the samples which you have forwarded, and which I presume have been only recently made.

The absence of free sulphuric acid in Vegetable Parchment having been satisfactorily established, it remained only to perform a few experiments on the strength of this material as compared with that of the animal parchment, with which it is likely to enter into competition. For this purpose, bands of vegetable and of animal parchment both $\frac{7}{8}$ of an inch in width, and as far as possible of equal thickness were slung round an horizontal cylinder, and appropriately fixed by means of an iron screw-clamp pressing both ends upon the upper part of the cylinder. The band assumed in this manner the shape of a ring, into the bend of which a small cylinder of wood was placed projecting on each side about an inch over the band and carrying by means of strings fastened to each end a pan, which was loaded with weights, until the band gave way. A set of experiments* made in this manner led to the result, that paper by exposure to the action of sulphuric acid in the manner described, acquires about

* The following are the details of these experiments:

WATER LEAF PAPER

broke, when loaded with

I.	II.	III.	Mean.
17 lb	15 lb	15 lb	15.6 lb

VEGETABLE PARCHMENT

broke, when loaded with

I.	II.	III.	Mean.
78 lb	75 lb	70 lb	74 lb

ANIMAL PARCHMENT

broke, when loaded with

I.	II.	III.	Mean.
92 lb	78 lb	56 lb	75 lb

The strips of vegetable and animal parchment were selected as nearly as possible of equal thickness, but the strips of the artificial product were somewhat heavier than those of real parchment. On an average the former weighed 18 grains, and the latter only 12.75 grains. Calculated for equal weights, the strength of animal parchment, as compared with that of artificial parchment, is obviously $\frac{18}{12.75} \times 75 = 105$. In round numbers, it may be said that vegetable parchment has three-fourths the strength of animal parchment.

five times the strength which it previously possessed, and that for equal weights, Vegetable Parchment possesses about $\frac{3}{4}$ the strength of animal parchment. It was found, moreover, that bands of Vegetable Parchment taken from different sheets of the same kind of paper, exhibited a remarkable uniformity of strength, whilst in animal parchment, which owing to its mode of manufacture, must always present considerable inequality of thickness, extraordinary variations were observed, even if the bands were taken from the same skin. These results differ somewhat from those observed by Mr. Barlow, who found the strength of Vegetable Parchment higher than it would appear to be from my experiments. This discrepancy may probably arise from the fact that Mr. Barlow experimented with specially prepared paper, whilst I operated purposely on samples representing the commercial article, such as it is manufactured on a large scale.

Vegetable Parchment, then, as far as strength goes, is not quite equal to animal parchment. On the other hand, the new article greatly surpasses real parchment in its resistance to the action of chemical agents, and especially of water. As has been already stated, vegetable, like animal parchment, absorbs water and becomes perfectly soft and pliable; but it may remain in contact, and even may be boiled with water for days, without being affected in the slightest degree, retaining its strength, and regaining its original appearance on drying; on the other hand, it is well known how rapidly animal parchment is altered by boiling water, by the protracted action of which it is converted into gelatine. Even at the common temperature, animal parchment, in the presence of moisture, is very prone to putrefactive decomposition, whilst parchment paper, in which nitrogen, this powerful disturber of chemical balance, is absent, may be exposed to moisture, without the slightest change either in appearance or properties. It would in fact be difficult to find a paper-like material endowed with greater power of resistance to the disintegrating influences of water than Vegetable Parchment.

Taking into consideration the chemical composition of the new material, its cohesive power, and its deportment with chemical solvents, especially water, both at the common temperature, and at the temperature of its boiling point, it is obvious that this substance unites in itself, in a most remarkable manner, the conditions of permanence and durability, and I have no hesitation in stating my belief that Vegetable Parchment properly prepared, is capable of resisting the tooth of time for many centuries, and that under various circumstances it will last even longer than animal parchment.

The valuable properties of Vegetable Parchment suggest a great variety of applications for the new material.

There is no doubt that parchment paper may be adopted, with

perfect security, for all legal documents, policies of insurance, foreign bills of exchange, bills of lading, scrip certificates, and other similar documents, as a substitute for the skins which are now generally used. On the other hand, its comparatively low price would appear to suggest its application in a variety of cases, in which, at present, paper is employed: for instance, for private ledgers of banking-houses, or other large establishments, as well as for registries of wills, marriages, baptisms, and deaths. Even for the manufacture of bank notes it may be found useful; indeed, for all documents, the preservation of which is of importance. Many of the documents in question, in order to protect them from injury in case of fire, are generally kept in safes, the majority of which are now encased with solid water,—the water of crystallization in alum, and other similar hydrated compounds. The interior of these safes, in case of exposure to heat, must, obviously, become filled with steam of a high temperature, and it cannot be doubted that documents written on Vegetable Parchment, owing to the extraordinary power with which this material resists the action of boiling water and of steam, will stand a much better chance of preservation under such circumstances, than those written on common paper or animal parchment.

As another advantage of Vegetable Parchment as compared with animal parchment, the experience may be quoted, that vegetable textures are much less attractive to insects than animal structures. Moreover, to increase the security of Vegetable Parchment in this respect, the paper, before conversion, may be incorporated with chemical agents, which, like salts of mercury for instance, have been employed with such advantage in the manufacture of paper for public records.

In considering the applicability of Vegetable Parchment for legal documents, another property of this remarkable material, although perhaps of minor importance, deserves nevertheless to be noticed. This is the great difficulty with which words are erased from its surface, and others are substituted in their places. Deeds written on parchment paper acquire thereby a certain degree of security against falsification.

Its strength and resistance to water appear to recommend parchment paper in an eminent degree for Engineers' and Architects' plans, and especially for their working plans, which are often unavoidably subjected to rough usage and moisture. The thinner sheets of parchment paper, on account of their transparency, present the additional advantage of being useful as a most durable tracing paper.

In consequence of its strength and resistance to water, Vegetable Parchment would probably find many applications for military purposes; thus it promises to furnish an excellent material for waterproof cartridges.

Another field of considerable extent for the application of Vegetable

Parchment appears to be in book-binding, and especially in ornamental book-binding. The books bound in parchment paper which accompanied your letter, are remarkable for the beauty and solidity of their binding. Experienced book-binders, to whom I submitted these books, believed them to be bound in real parchment. Even in the manufacture of books and maps which, like those used for educational purposes, like military plans and nautical charts, have to stand considerable wear and tear, parchment paper may find a very useful application. The printing on ordinary paper is not changed by the treatment with sulphuric acid, but owing to the shrinking of the paper during the process, it will, probably, be found more convenient for such purposes to print on the paper after it has undergone the transformation. Vegetable Parchment is remarkable for the facility with which printer's ink, as well as writing ink may be applied to it, and for its attraction for dyes generally, many of which it appears to take even more readily than calico. The specimens of dyed parchment paper, which accompanied your letter, leave nothing that could be desired in this respect.

Among the numerous more or less important applications in which parchment paper is sure to be found useful as soon as it becomes accessible to the general public, its adaptation for household, and especially for culinary purposes must not be left unmentioned.

In closing the orifices of vessels for preserves, &c., few housewives will hesitate to substitute an elegant material like Vegetable Parchment paper for the animal membrane, so frequently offensive, which is now generally in use.

Formed into bags of which the seams are cemented with the white of egg, parchment paper will be found very useful for the purposes of boiling and stewing, according to the principles of a refined and scientific *cuisine*.

Nor can the chemist fail to derive some benefit from so interesting an achievement of his own science as the transformation of paper into parchment.

In the laboratory, Vegetable Parchment will become a material of general use for connecting retorts and condensers, or other similar apparatus, and on account of its indestructibility by many of the fluids usually employed in electric batteries, it will probably find a further and even more important application in the construction of diaphragms for galvanic apparatus.

I have the honour to be,

Gentlemen,

Your obedient servant,

A. W. Hofmann.

Messrs. Thomas De La Rue and Co.